Intense Energy, Vorticity, and Strain Focusing in Nonlinear Fluid Flows

Daniel P. Lathrop, University of Maryland,
PECASE DMR-9896037
DMR-0244581

We have explored focusing of energy into jets in extreme surface waves (Nature 403, 401: Jan. 27, 2000), and the focusing of strain and rotating motions in turbulent flows with violent vortices (Nature 421, 146: Jan. 9, 2003).

The image to the right shows a multiple exposure of a collapsing surface wave and its resulting upward jet. These experiments show the unusual nature of surface wave dynamics which can lead to important effects in engineering flows and ocean surfaces. This research addresses how energy can be gathered into a small portion of a moving fluid by self-focusing, and how that focusing is effects by polymers or magnetic fields.

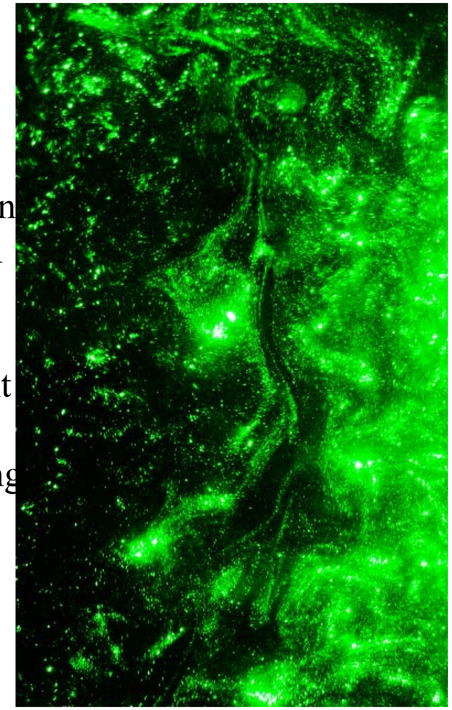
Research at the University of Maryland in the lab of Dan Lathrop examines a number of different fluid flows where violent events occur due the nonlinearities in the laws governing fluid motion. The image here shows a surface wave which has been driven to form an upward jet reaching 200 MPH -- caused by the focusing of the wave energy into the central portion. By building mathematical models of this type of motion, and analogous situations in turbulent flows, their lab hopes to be able to predict and understand the causes of unusual, rare events occurring in a wide variety situations.

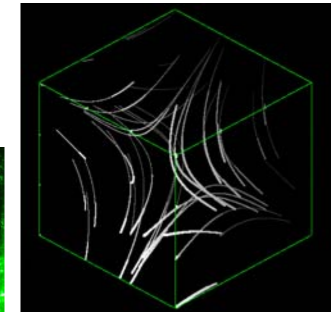
Intense Energy, Vorticity, and Strain Focusing in Nonlinear Fluid Flows

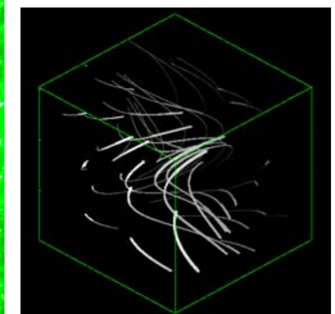
Daniel P. Lathrop, University of Maryland,

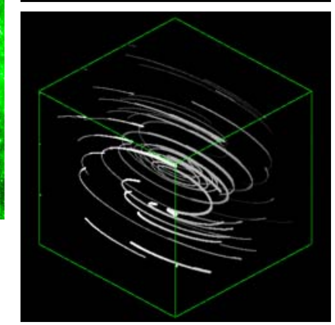
PECASE DMR-9896037
DMR-0244581

Turbulent flows exhibit intense bursts of vorticity and strain. Turbulent intermittency can be important, for example, for enhancing the mixing of chemicals, by producing sharp drops in local pressure that can induce cavitation (damaging mechanical components and biological organisms), and causing intense vortices in atmospheric flows. Our research has examined the cause of local intense strains and rotational motions in turbulent flows using new optical laser diagnostics. These studies are important for modeling and predicting turbulent flows. Ongoing research explores how these flows are modified by drag-reducing polymers, and how the polymers are effected by the flows.





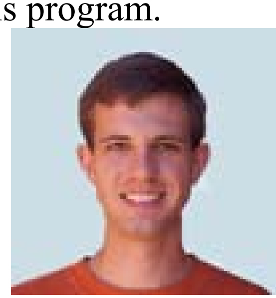




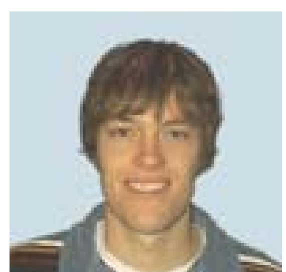
Education/Outreach:

The mentoring of students is an important part of this research. Seven Ph.D. students and seven undergraduates were involved. Outreach includes public talks and tours for the Maryland MRSEC middle school girls program.

Ben Zeff
Ph.D. student

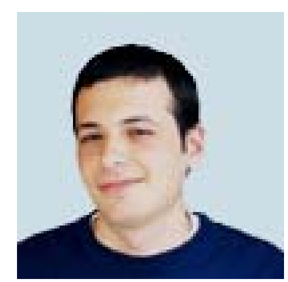


Dan Lanterman
Ph.D. student



Woodrow Shew
Ph.D. student

Barbara Brawn
Undergraduate



Dan Blum
Undergraduate

The research done on nonlinear fluid flows and focusing has broad impact on understanding of turbulence in engineering applications, geophysical flows such as turbulence in our atmosphere, and surface waves on the ocean. Additional importance of this type of university research comes about from the training of new generations of researchers and scientists. How our young aspiring researchers fare now impacts our countries ability to perform into the future in science and technology. This research group at the University of Maryland has been particularly successful at involving groups of graduate students together with undergraduate researchers involved in summer and semester projects.